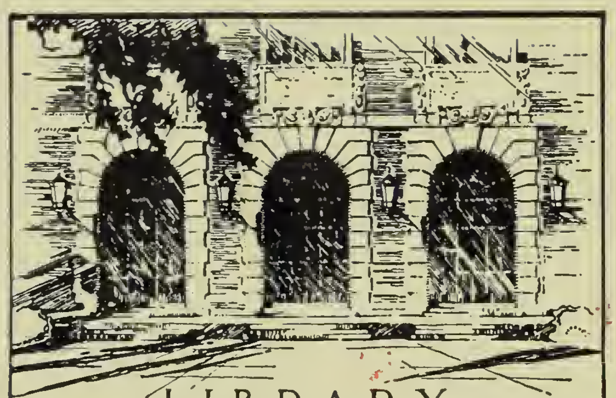

BULLETIN OF THE UNIVERSITY OF UTAH

Volume 35 | January 17, 1945 | No. 12

The March of Medicine

BY

DR. M. M. WINTROBE

Professor and Head of the Department of Medicine

Ninth Annual Reynolds Lecture

January 17, 1945

UNIVERSITY OF UTAH

Salt Lake City, Utah

Previous Lectures

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The Reynolds Lectureship

The Annual Reynolds Lectureship at the University of Utah serves a double purpose.

First, through a distinguished member of its faculty, the University presents an important yearly offering to the public.

Second, the Lectureship commemorates in a fitting way the unique service of Professor F. W. Reynolds to the institution and to the State.

The committee on selection consists of ten members including the President of the University, and the Director of the Extension Division. This committee acts upon recommendations of the Deans who are made responsible for nominating faculty members of outstanding accomplishment in their schools.

It is gratifying to the originators of this project and to those who have made contributions for its support that the Reynolds Lectureship has now become firmly established as a University function—promoted and administered by the University.

H. L. Marshall

President of the Reynolds Association

The March of Medicine

With the establishment of a full four year medical school in this university, it is perhaps fitting that the faculty and the community in general stop to consider the past, present and future of medicine. I make no excuse for failing to discuss some philosophical subject and for bringing up such practical matters as medicine and public health. These are so important to our daily life and have so profound an influence on the social, economic, political and even intellectual and literary aspects of our existence, that they deserve adequate consideration. The advances of medical science in modern times have been phenomenal when compared with the slow progress which was being made until 100 years ago. Indeed, the pace has been so rapid in recent years that we have fallen far behind in the application of these discoveries for the benefit of humankind.

The Origins of Medicine

The progress of medicine, as might be expected, has been closely tied with the advance of civilization. The Golden Age of Greece, the Roman period, the Dark Ages, the Renaissance are all reflected in the history of medicine for in these same periods medicine advanced or declined as did civilization itself. But the opposite was also true. Civilization declined in part as the result of disease. Malaria contributed in large measure to the decadence of Greece. The Greeks who surrendered to the Roman legions were very different from those who had fought off the Persian invaders. Malaria, according to Jones[1], an outstanding student of Greek medicine, changed them from brilliant, energetic, original individuals full of initiative, high spirit and patriotism to vacillating, weak, cowardly and selfishly cruel ones. No doubt other factors played their part as well but there is no question that a disease like malaria can sap the vitality of a people. In later years, the great plagues and epidemics were calamities which impeded civilization for centuries. The economic advancement of many parts of the world today is greatly retarded by the prevalence of disease.

In the medicine of Ancient Greece we see the dawn of scientific medicine. This refers not to the mythical Asclepios (Aesculapius) and the legendary serpent, or to the medicine of the sanctuaries and of the priests, but to the emergence of the practice of direct observation. Before this period medicine was variously empirical, magical, priestly or religious. There had been no concern with the discovery of fundamental causes and there was no attempt to arrange in logical sequence the cause and effect of observed phenomena. The development of scientific medicine was contemporary with the emergence of Greek philosophy. Comparable with Pericles, Herodotus, Thucydides, Phidias, Sophocles and Euripides, was Hippocrates. He was undoubtedly the most important and most complete medical personality of antiquity[2]. He was born about 460 B. C. on the small island of Cos.

Objective observation was the feature of the Hippocratic School. It has been stated that the 47 clinical histories contained in the Hippocratic writings are the only ones worthy of the name to be found in medical literature for the next 1700 years[3]. The honesty and sincerity of Hippocrates is illustrated by his citing the fact that 60 per cent of his cases ended fatally. In his own words, he believed it "valuable to learn of unsuccessful experiments and to know the cause of their failure." He made no attempt to magnify his own importance by hiding his own lack of knowledge or failures. The "Oath of Hippocrates," now familiar even to some lay persons, expressed the high ethical level to which medicine rose in the Golden Age of Greece.

The inspiring period of Hippocrates was followed by an astoundingly long period of stagnation and decadence, interrupted only by rare and relatively minor contributions. One of the few outstanding figures was Galen (131-201 A. D.), physician to the Emperor Marcus Aurelius. To Galen are attributed wide and original discoveries in anatomy, physiology and disease in general as well as in the use of various drugs. But this was a very different manner of man, who was equipped with the highest opinion of his own value and was sure of his own infallibility. He constructed an extensive edifice of dogma.

With pestilences mysticism returned. The viewpoint which made disease the punishment for sin was no stimulus to the search for the causes of disease. For centuries none disputed the oracular pronouncements of the past even though illustrious physicians appeared from time to time. The Persian philosopher, Avicenna, was the most renowned of the Golden Age of Arabian medicine in the tenth century. His famous Canon (Q'anun) followed the ideas of Hippocrates, Galen and Aristotle and constituted a statement of authoritative, scholastic dogmatism.

Medicine and the Renaissance

The reawakening of a critical spirit, the rebellion against authority, the promulgation of the system of Copernicus, the discovery of America, and events of similar magnitude during the Renaissance were accompanied in the field of medicine by a violent revolution against the authority of the ancients. The beginning of the modern experimental period may be said to date from Paracelsus, a strange combination of sorcerer, philosopher, alchemist and physician of this time. The keynote of the teaching of Paracelsus was that men should search into the workings of nature for themselves. He startled the world by publicly committing the Canon of Avicenna to the flames of a students' bonfire.

This period was marked by the work of Vesalius who laid the foundations of modern anatomy, William Harvey who discovered the manner of circulation of the blood and Thomas Sydenham who demonstrated the value of accurate descriptions of the signs and symptoms of disease in the place of vague theories. The Italian Morgagni, laid the foundations of morbid anatomy by examining

great numbers of bodies after death. He carefully and systematically recorded everything which he found abnormal and tried to correlate this with the signs and symptoms in the individuals before they died. The best type of medical practice requires this even today for our knowledge is still very incomplete.

The new approach in medicine gradually proved its value. Following the example of his teacher, John Hunter, Edward Jenner had the courage to test the Gloucestershire tradition that milkmaids who had contracted cowpox from milking did not get smallpox. Countless lives have been saved and much disfigurement and blindness prevented by the method of vaccination which developed from Jenner's simple experiment. The discovery by James Lind of the importance of fruit juices in the prevention of scurvy was significant not only medically but also politically and economically for the might of the British Navy depended on the health of the British "limeys," as their sailors came to be called.

Eighteenth Century Hospitals and Sanitary Conditions

But progress was extremely slow. In the eighteenth century, hospitals were for the care rather than the cure of their inmates. So prevalent were erysipelas, pyemia, septicemia and gangrene in these institutions that they came to be known as the "hospital diseases." Such pestilences would come upon the patients and kill them like flies. At the Hotel Dieu in Paris, six unhappy patients, in various states of physical and mental disorder might be heaped all in one bed. No one who had a home would go to a hospital; nor did they need to for after all such hospitals offered no facilities except for the spread of disease.

Sanitary conditions were equally horrible. In the towns of 18th century England the streets were made as narrow as was feasible and were often barely passable from mud or tolerable from stench. "In places where house drainage was connected up with sewers these generally ran directly into the local river, canal or stream with the natural result that such water became a stinking open drain."[4] Water was inadequate in supply. While famine and leprosy and plague were no longer as important factors as they had been, intermittent and remittent fevers, dysentery, malaria, typhus, scurvy, cholera, yellow fever, influenza, measles, diphtheria and scarlet fever were rampant.

The Microscope, The Animal Cell and The Germ Theory

Thus, although medicine gained an impetus in the Renaissance, progress was slow. The new advances had to await the discoveries in other fields of science—physics, botany and chemistry. The great physicians had developed their powers of observation to a high degree, but this did not suffice. It was necessary to amplify the powers of the sense organs, and particularly those of sight.

The invention of the *microscope* has been attributed to Roger Bacon, who lived in the 13th century but Galileo, in the 17th century was perhaps the first scientific user of this instrument. To the

spectacle makers, however, we owe the development of the microscope, and particularly to Antoni van Leeuwenhoek, a man who had never attended a university and was entirely self taught. He constructed a number of microscopes and studied all types of matter, even including the red blood corpuscles whose diameter he measured.

A decisive factor in medical progress was the discovery of the *animal cell* and the establishment of the fact that the living body is a vast organization consisting of innumerable individual cells so small that they can be seen only with the aid of a microscope. Schwann, and later Rudolph Virchow applied the discoveries of the botanists, who had demonstrated the cellular constitution of the vegetable kingdom, to the intimate study of disease. This was the foundation of the science of pathology.

There is no doubt that one of the most important contributions of the 19th century to medicine was the demonstration of the fact that invisible organisms, so small that they can only be seen with the aid of a microscope, may cause disease. Such organisms had been observed in the 17th century but two centuries passed before their significance was appreciated. In the 19th century, thanks to the work of Pasteur, Koch and others, a revolution in the structure of medical thought occurred. It was finally recognized that infinitely small organisms, endowed with special pathogenic qualities, may play a preeminent role in producing disease.

At the same time that Virchow was laying the foundations of pathology in Germany, Pasteur developed the *germ theory* in France. Pasteur was a chemist and in that field his earlier studies led him to the discovery that putrefaction is a kind of fermentation and that both these processes are due to micro-organisms. He showed that the disease of wine which plagued the wine industry in France was due to the action of microbes and that by heating the wine for a short time to a temperature between 50 and 60° C., the fermenting agent could be destroyed while the wine would remain unaltered and would keep indefinitely. This process is now well known under the name, "pasteurization."

A name equal in importance to that of Pasteur in founding the science of bacteriology is that of Robert Koch. This man was a district physician in a small Prussian town. His thoughtful wife gave him a microscope on his 28th birthday. We owe her a very great debt for Koch went to work studying anthrax, a disease common among the sheep and cattle of his agricultural district and thus initiated a series of investigations which revealed the causes of a great number of diseases, including tuberculosis. Before the close of the 19th century there had been discovered the causative agents of gonorrhea, suppuration, typhoid fever, malaria, cholera, diphtheria, certain types of pneumonia, cerebrospinal meningitis, Malta fever, tetanus or lockjaw, plague, botulism and dysentery.

The story of the attack on germs, once they were recognized, is an exciting and fascinating one. Investigators became interested in the method of spread of organisms. There were many proponents of the idea that the air is bad and that in this way organisms causing disease are transmitted. It has been aptly stated[4] that it was easy

to blame the air since no one owned a vested interest in it. It was more dangerous to find fault with the water supply for this had its sturdy champions in the directors of the various water companies. Yet in many places the water supplies were nothing more nor less than diluted sewage.

It is well known now that tuberculosis, diphtheria, undulant fever, typhoid and a number of other diseases can be transmitted by infected water, milk or other foods. Yet it has not been easy to convince people of this fact and many communities still tolerate laxity in sanitary legislation. Special interests concerned only with financial gain and officials unaware of the importance of sanitation are permitted to take risks with human life.

The newer knowledge of the bacterial causation of certain diseases naturally led many to wonder why only certain individuals were attacked by such bacteria and why even when attacked some did not succumb. It had been recognized for centuries that individuals attacked by certain diseases were not likely to be attacked again. Study of the mechanism whereby the body is able to withstand the action of bacteria led to the development of the science of immunology. Once some knowledge was gained of the protective mechanisms which we possess, scientists were challenged by the problem of developing and improving this protective faculty. Thus have come antitoxins, serums and vaccines and the saving of countless lives.

The Development of Surgery

In Roman times each soldier kept with him a kit of bandages for use on himself or for a wounded or bleeding comrade. Such measures served well enough for minor injuries. Those who were so badly wounded that they were unable to move along with the advancing troops were put to the sword. The able-bodied but wounded soldier who fell into the hands of the enemy could only expect to be insulted or mutilated, if not killed. During the Middle Ages some men of doubtful qualifications made it their trade to treat soldiers for a meager stipend just as mercenary soldiers took up warfare as a business. Field hospitals were introduced by Isabella of Spain around 1487 and they were later re-introduced by her grandson at the siege of Metz in the 16th century. There Ambroise Pare’ was a central surgical figure. He was responsible for abolishing the custom of applying cautery or boiling oil to wounds. In the 17th century the regimental surgeons were still referred to as staff barbers and that is about what the great majority of them were.

The development of surgery was hampered by the lack of means for controlling pain and it was plagued by the high mortality which attended it. Such surgical deaths were due to hemorrhage, traumatic shock and infection. Infection was a concept wholly unfamiliar before the 19th century. A favorite method of procedure of 18th century surgeons, as well as of those who preceded them, was to probe wounds. The probes were not sterilized and often were not even washed. The surgeons themselves wore their oldest frock coats in the operating room. To these coats, often heavily

encrusted with dried blood and pus, some surgeons even attached an aura of superiority.

Surgery in the 18th century consisted of the setting of broken bones, the probing and suturing of wounds, the amputation of crushed or gangrenous limbs and the opening of abscesses. No one dared to attempt abdominal surgery. Operations for gall bladder disease, thyroid disease and cancer, which make up so large a part of a surgeon's work today were unknown. Appendicitis had not been recognized.

It was at the turn of the 18th century that one of the many dramatic events in the history of surgery took place. In Danville, Kentucky, on Christmas day, 1809, Ephraim McDowell performed in his own home an operation such as had never been done before. This was the removal of a large abdominal (ovarian) tumor, without the benefit of anesthesia, and without the aid of adequate methods for stopping hemorrhage or for preventing infection. Since her life depended on it, his stalwart patient agreed to undergo the ordeal. McDowell's fellow citizens also knew that the operation was experimental and it is told that a crowd gathered outside of his house with the intention of hanging him if his patient should die. Fortunately for McDowell, and for the progress of surgery, the operation took no more than 25 minutes and the patient recovered completely.

This amazing performance found few imitators for it required extraordinary courage on the part of both the patient and the surgeon. We may be proud that the problem of relieving pain was solved by two Americans who quite independently of each other in the early 1840's discovered the anesthetic powers of ether. One was Dr. Crawford W. Long, a general practitioner in a little town in Georgia. He first operated with ether anesthesia in 1842. He did not publicize his discovery and the credit for making the use of ether known to the world is given to the Boston dentist, William T. G. Morton and to the staff of the Massachusetts General Hospital where the regular use of ether began in 1846.

To Joseph Lister must be given the credit for initiating the conquest of surgical infection. In 1872 at the Bellevue Hospital in New York from 40 to 60 per cent of all amputations of limbs proved fatal. The same was true at the University of Glasgow when Lister took the post of Professor of Surgery there. Lister was impressed by Pasteur's demonstration that organisms that produce fermentation and putrefaction are carried on particles of dust in the air. He decided to try to prevent infection by using on wounds a dressing containing a material capable of destroying micro-organisms. Using crude carbolic acid he developed the first antiseptic dressing in March, 1865. Two years later he was able to report a total of 11 cases of compound fracture treated by the antiseptic method with 9 recoveries, 1 amputation and 1 death. Pyemia, hospital gangrene and erysipelas disappeared. These were unprecedented results, as dramatic in their day as any we are seeing today.

An equally important contribution was Lister's discovery of a method of preparing a relatively sterile, absorbable catgut with

which wounds could be sewn. This procedure made it possible for wounds to heal in the clean and straightforward way to which we are accustomed today. Until this time pus formation was so common that it was regarded as part of the healing process and was spoken of as "laudable pus."

We can now appreciate how great were Lister's contributions to humanity. In his time, he met much opposition. His untiring investigations on ligatures were carried out in animals and the Anti-Vivisectionists in England made repeated attempts to prevent him from continuing his experiments. Furthermore, his own associates were too stubborn to appreciate the value of his discoveries and as late as 1880 in all the British Isles there were only one or two clinics where his methods were used. Fortunately in Germany, and subsequently in this country, a number of surgeons began to apply his methods and to find them of the greatest importance. The German surgeons not only adopted Lister's methods but they developed the essentials of the modern aseptic technique which is actually quite different from Lister's antiseptic method. They showed that the dangerous or so-called pathogenic bacteria were conveyed to wounds by the hands of surgeons and nurses or by instruments and dressings. Boiling was discovered to be an effective means of sterilization. It is significant, however, that as late as 1883, 18 years after Lister's discovery, as Haagensen and Lloyd[4] record, "In the discussion of a paper on Lister's doctrine before the American Surgical Association, leading surgeons from many parts of the United States almost without exception condemned his methods, saying that they had tried them and had no success with them. The truth, of course, was that they had not tried them out with the requisite attention to detail, and so they failed."

At the Johns Hopkins Hospital there are two buildings of interest at this point in our story. One is the Halsted Clinic which is the surgical building, and the other is Hampton House, the nurses' home. At Johns Hopkins the first Professor of Surgery was William Stewart Halsted and at that time the nurse in charge of the operating room was Caroline Hampton. She complained that the solution of mercuric chloride used for rinsing the hands before scrubbing, caused dermatitis. Dr. Halsted had the Goodyear Rubber Company design a pair of rubber gloves for her. Their advantage from the viewpoint of protecting the patient from infection introduced by the operator became obvious and they have been used ever since. It is significant, however, that Dr. Halsted and Miss Hampton were married shortly after this glove episode. It has been suggested that, "This discovery, certainly one of the most important means of avoiding wound infection, was perhaps not entirely the result of scientific zeal."[4]

Halsted proved to be a quiet but effective force in this country in transforming surgery from a series of dramatic and somewhat dangerous incidents into a less conspicuous, painstaking and more successful method of treatment. He developed means for the control of hemorrhage during operation which gave to the surgeon in Halsted's words, "the calm which is essential for clear thinking and

orderly procedure at the operating table." He, as well as Crile of Cleveland, taught the importance of gentle handling of the tissues. He devised operative techniques which are still followed today.

It would be impossible to discuss all the advances which have been made in surgery since the latter part of the 19th century. The recognition of appendicitis as a disease entity and its surgical treatment have saved thousands and thousands of lives. The advances in operative surgery of the gastro-intestinal tract, in operations on the female genital tract, in thyroid surgery, in orthopedics, in neurosurgery and, only very recently, in chest surgery have been truly phenomenal and have saved countless lives and prevented untold suffering. In spite of a very great increase in the amount of surgery performed, and in the extensiveness of operations in which surgeons now engage, the over all operative mortality in one of the better hospitals in this country dropped from 16.5 per cent in 1889 to 2.1 per cent in 1939.[4] These advances, as well as other discoveries which will be mentioned later, have profoundly influenced the prospects of the battle casualties of the present day.

The Evolution of Diagnostic Methods and of Our Understanding of Disease Processes

Less dramatic but equally important have been the advances in methods for recognizing disease and in the understanding of the disturbances which various diseases produce. The early physician had to rely solely on his senses of sight, touch, hearing and smell. Although his powers of observation were developed to a high degree, and necessarily so, the interpretation of his findings was often erroneous because his knowledge was so limited. Examination of the pulse was practised even by the early Egyptians. Temperature was estimated with the hand applied to the chest. Santorio, an Italian of the 16th century, was perhaps the first to use a thermometer but until the 19th century the apparatus available was cumbersome and was used by very few. The thermometer is one of the first instruments of precision to aid medical practice but it did not become a necessary part of the physician's armamentarium until the time of Wunderlich in the latter half of the 19th century. The modern simple instrument was only devised in the present century.

Examination of the urine was also practiced in the early days of medicine. The Arabian physician, Avicenna, wrote lengthily on the subject. Uroscopy or water-casting, as it was called, became such a regular practice that the urinal became the emblem of the physician in the Middle Ages and was a favorite theme of the painter and wood-engraver. Sometimes the urine was carried to the physician by a messenger and the diagnosis made "by mail-order." Although this method had no true diagnostic value it was pushed to fantastic extremes and led to the most far-reaching conclusions. It was not until the late 19th century that the chemical procedures for the examination of the urine and of the blood which we now use were developed.

Tapping of the chest, which is so familiar today and which has proved to be a very valuable aid in physical diagnosis, was received with ridicule and sarcasm in 1761 when Leopold Auenbrugger proposed the procedure. It is interesting that he was led to this discovery when he observed that the level of fluids in his native wine casks could be ascertained by thumping. Auscultation, that is listening, to the chest was practised by Hippocrates and was aided by shaking the chest. This was done by placing the ear to the chest until Laennec (1817) invented the first stethoscope. He gained his idea for the use of a hollow tube by observing children listening to the sound of taps on hollow logs.

The x-ray was discovered in 1895 and, like so many other discoveries, had its beginning in an accident. It was by mere chance that Roentgen was working in the dark with a tube of glass containing various gasses at low pressures (the Crookes' tube) and happened to notice that a small piece of paper covered with a coating of barium plantinocyanide shone brightly. Fortunately he had the foresight to suspect that this might be of importance and the persistence to investigate the possibilities until he obtained convincing evidence of the value of these strange rays. This discovery was one of the most dramatic events in the history of science. As an example of how the imagination of the world was stimulated by it, the bill may be cited which Assemblyman Reed of New Jersey introduced in the state legislature in 1896 to prohibit the use of x-ray opera glasses in theatres!

In the 19th century, knowledge of disease was sought mainly through studies of morbid anatomy; that is by observing the effects which disease produced on the tissues. Gradually interest developed in the study of the ways in which the functions of the body are disturbed in disease—pathologic physiology and biochemistry. This approach bore fruit because with better understanding of disease processes methods were developed whereby disease may be recognized much earlier than it once could be. Furthermore, such knowledge has led to the discovery of methods of treatment which are directed at the primary cause or at least correct the abnormality which has been produced.

Advances have been made in so many fields that it would be impossible to discuss them all here. Many problems relating to man have been approached through experiments in animals and it is safe to say that they would probably never have been solved otherwise. An example is found in the story of the conquest of diabetes.

In 1920, Frederick Banting, a physician in London, Ontario, while preparing a lecture at the Western Ontario Medical School on the relation of the pancreas to diabetes, ran across the report of a rare case of stone in the pancreatic duct. The author of that report pointed out that blockage of the pancreatic duct by the stone had caused atrophy of all the pancreatic cells except certain small groups known as the "islets of Langerhans." These were the cells which were known to be damaged in persons suffering from diabetes. In the case cited, diabetes had not developed.

It had been known for more than 30 years that the pancreas was related to diabetes and a number of investigators had attempted without success to isolate the secretion of the cells contained in the islands of Langerhans. Banting was struck by the thought that by tying the pancreatic duct of animals it might be possible to obtain the secretion of the islet cells and that an extract of the cells might actually relieve the high blood sugar found in diabetes. He was so obsessed with the idea that he got up at two in the morning and wrote three sentences in his notebook. "Ligate pancreatic duct of dogs. Wait six to eight weeks for degeneration. Remove the residue and extract."

It is significant that when he went to Toronto to talk to the professor of physiology there, Dr. J. J. R. Macleod, he got little encouragement. Some years later this same MacLeod together with Banting received the Nobel Prize for Banting's great discovery. Fortunately, Banting's determination won out and with the aid of a medical student, Charles H. Best, he succeeded in making an extract of the islets as he proposed. Banting and Best operated on the first dog on May 16, 1921. By January 1923 insulin was being successfully used in the treatment of human diabetes in a number of clinics in Canada and the United States.

The discovery of the treatment of diabetes is closely linked with that for pernicious anemia for George R. Minot, who is mainly responsible for the latter, himself was suffering from diabetes and might not have lived to make his important studies in pernicious anemia. This disease was so called because until 1926 it inevitably led to death. The story of Minot's success is one of painstaking study, patient observation, and persistent effort in the face of personal ill health as well as frank skepticism and even open criticism from his colleagues. It was naturally not easy to accept the idea that a pale, exhausted looking patient must consume a half pound of liver daily and could expect to get better thereby. It was indeed a great surprise to discover that after only a few days of liver therapy such a patient craved food, color appeared in his face and his outlook had changed. The development of an extract of liver which is so potent that one injection per month or less often is sufficient to maintain such a patient in normal condition, is the natural outcome of the researches which Minot's perseverance initiated.

The story of the vitamins is another impressive chapter in the history of medical science. Deficiency diseases have been known for a long time. Scurvy hampered the crusaders and ravaged the sailors of Vasco da Gama and of Cartier. It came to be known as "the plague of the sea and the spoyle of the mariners." The Spaniards and the Italians knew pellagra and recognized that it was associated with the eating of unsuitable food. Glisson described rickets, which term is derived from the old English verb meaning "twisted," in 1650. Beriberi ravaged the Japanese Navy at the turn of the last century and plagued the Phillipines for many years.

That there exist substances necessary to life although required only in relatively minute amounts is, however, a relatively new concept. The term "vitamin" was introduced in 1911. For many years these substances were so mysterious that the letters of the alphabet were used to name them and they were known only by the effects of their absence. Their total number in those earlier days was not even suspected. Today, when we know the chemical formulas of more than 14 of these remarkable substances, it is recognized that still others remain unrevealed. The demonstration of their widespread physiological action and of the effects of their administration in conditions of deficiency has been one of the most important achievements in the present era.

This newer knowledge has been worked out for the most part in animal experiments. The first experimentally produced deficiency disorder came about largely by accident. In the Dutch East Indies, Eijkman was engaged in certain experiments with chickens when his stock diet of chicken feed ran out. He was forced, as a consequence, to give them the table scraps from the adjoining hospital. Since the diet of the natives consisted almost exclusively of polished rice, this is what the chickens received. Great was the surprise when the chickens developed a disorder resembling the beriberi which was so prevalent in the East Indian Islands. Eijkman soon found that the skin of the rice kernel or even the rice bran relieved the condition in the chickens. Thus was the first of the "B" vitamins discovered.

The rat became the favorite animal for experiments in nutrition. The chick, the dog, the guinea pig and more recently the rabbit, the pig, the mouse and the hamster and even bacteria have played their role in advancing the science of nutrition. We have learned how vitamin A is important for vision and how night-blindness develops in its absence; how important thiamin is for the heart, and we have seen the extreme shortness of breath that develops in the pig in its absence; how riboflavin is concerned with growth and with the eyes, for in its absence cataract may develop; how sick dogs became in the absence of niacin. We have seen pigs lacking vitamin B_6 suffer from severe convulsions, become extremely anemic and develop a peculiar gait. It has been shown that the hair of the black rat turns gray in the absence of pantothenic acid and that the pig becomes bald, ceases growing, and becomes unable to walk. We have learned how in a guinea pig lack of vitamin C leads to serious hemorrhages in the tissues and death; how the rat in the absence of vitamin E becomes sterile and the rabbit develops certain peculiar changes in the muscles; and how the chick lacking vitamin K is the victim of a severe hemorrhagic state. The chemical structure of many of these substances has been discovered. Great strides have been made in understanding their mode of action. This has meant learning in detail about the finer chemical processes on which life and growth depend.

It has been demonstrated too, that various species of animals differ in their needs for the different vitamins and that the manifestations of deficiency are not always the same in all animals. As far

as man is concerned we have already learned about the dramatic effect of niacin in pellagra and the importance of vitamin K in certain types of hemorrhage, while man's need for vitamin C and vitamin D are by now old established facts. But there is a great deal with reference to man which is still unknown, a fact which those seeking financial gain by the sale of vitamins choose to ignore. Much has been claimed for which there is no adequate scientific basis. In no field has the public been given so distorted a picture as in that of the vitamins.

The Present Day "Wonder Drugs"

When the present era of medicine will be history, it will probably be called the "Therapeutic Period." As one scans the development of medical knowledge since the Renaissance, three earlier Periods can be made out. The first is the Anatomical, when students of medicine sought to learn about the structure of the human body. As this knowledge was gained, curiosity was aroused as to the manner in which these organs function—the Physiological Period. The study of the structural abnormalities produced by disease was closely correlated with a search for the causes of disease and the study of the mechanisms whereby disease is produced. This may be designated as the Etiological Period. Obviously these periods are not sharply separated from one another nor can the study of structure, function, causes and mechanisms be regarded as now completed. These divisions follow one another naturally, however, and the knowledge so gained is a necessary prerequisite to the development of intelligent and effective methods of treatment.

The fantastic methods of treatment which were practised in the earlier days of medicine, like the criminal hokus pokus of the charlatans and quacks of today, were founded in ignorance and flourished thereby. The advances in our knowledge in the last 75 years have been so great that it has been possible to devise for certain diseases specific methods of treatment, and to apply such methods with understanding. The advances in surgery have been described already; the development of antitoxins, serums and vaccines has been mentioned and the discovery of such substances as insulin, liver extract and the vitamins has been discussed. The most dramatic advances of all have been made in the field of chemotherapy, by which is meant the treatment of disease by specific drugs.

Some years ago at the University of California there was a celebration commemorating the 300th anniversary of the introduction of quinine, in the form of Peruvian or Jesuit's bark, into medicine. On that occasion the late Dr. William H. Welch said that the introduction of this drug into medicine was as important as the whole concept of infectious disease because prior to its discovery all forms of treatment were directed either to purging, to sweating or to causing increased urination in the patients in the hope of expelling evil humors.

Modern chemotherapy had its beginnings in the work of Paul Ehrlich, at the turn of the present century. This diligent investigator

devised the technique of synthesizing many new drugs of slightly varying chemical formulas and testing each experimentally. He began by studying the effects of drugs in destroying a unicellular organism, a trypanosome which had just been discovered to be the cause of a disease of horses and which could be transmitted for experimental study in mice. When, not long after, the cause of syphilis was revealed he was prepared to attack the spirochete in the same way. The story of Ehrlich's epoch-making contribution is one of incredible tenacity. It was his six hundred and sixth arsenical compound, salvarsan, which had the desired effect.

Ehrlich's object was to sterilize the body of the parasites without injuring the body tissues. He sought to do this by giving the experimental animal or the patient a substance which could be taken internally and thus his purpose differed from that of Lister who proposed to destroy bacteria which might have reached an external wound, or that of the "aseptic" school which tried to prevent access of bacteria to a wound. Ehrlich's task proved to be a difficult one for neither "606" or his later compound "914" accomplished such internal sterilization without sometimes causing grave injury to the patient. Nevertheless these agents have proved to be extremely effective for the treatment of syphilis and the risks involved have been far surpassed by the results accomplished.

It was not until more than two decades later that another compound was found equal in importance to the organic arsenicals produced by Ehrlich. It is significant that the methods used for the discovery of the new drug were essentially the same as those devised by him. As long ago as 1915 two American workers[4] studied the bactericidal properties of a large series of azo dyes including several sulphonamide compounds. They limited their observations to the action of the dyes upon bacteria in the test tube and they did not study the effect of these dyes in animals. It remained, therefore, for Dr. Gerhard Domagk at the I. G. Farbenindustrie in Germany to discover an effective chemotherapeutic agent against hemolytic streptococcus infection in mice.

Unlike the other great discoveries which we have described, the finding of a chemotherapeutic agent effective against streptococcus infections was made by the employee of an industrial firm interested in financial gain and in a Germany very different from that which nourished Virchow, Koch and Ehrlich. The therapeutic agent which Domagk discovered was patented under the name of "prontosil" in 1932 but no notice of this patent was published until 3 years later. A few German clinicians were given the compound for testing in patients but they were not informed as to its nature. Their clinical reports did not appear until 1935. "The I. G. Farbenindustrie had apparently withheld knowledge of the therapeutic value of prontosil so that its chemists could have time to prepare and test a large number of chemically related compounds."[4]

The keenness of French chemists ruined the German effort to control the important discovery. The French workers concluded that the effective agent in the mysterious "prontosil" must be p-aminobenzene sulfonamide, or sulfanilamide for short. This proved

to be the case. Since sulfanilamide was a compound known to chemists even in 1908, it could not be patented. The complete information was then given to the scientific world.

In England, Colebrook confirmed Domagk's animal experiments and was able to produce convincing evidence that the new chemotherapeutic agent was effective in man, something the Germans had failed to do. He showed that by the use of prontosil or with sulfanilamide the mortality from puerperal sepsis or childbed fever, the great hazard of childbearing, could be reduced from between 16.6 and 31.6 per cent to 4.7 per cent.

The story that follows is one of discovery of new compounds, modifications of the original ones. Sulfapyridine, sulfathiazole, sulfadiazine and sulfamerazine now are names familiar to everyone. Administered to human beings ill with lobar pneumonia, sulfapyridine reduced the mortality of the disease from about 25 per cent to 5 per cent. All the tediously produced and costly pneumonia antisera were superseded over night. In certain other infectious disorders equally dramatic effects were observed. The results following the use of the sulfonamides have been truly revoluntionary. These agents have proved useful not only in treatment but also have been found valuable in preventing the spread of certain types of infections such, for example, as cerebro-spinal meningitis, which might otherwise have developed into epidemics.

> "Medical news last week vie with news of the days before invasion. Under the aspect of eternity, the medical news might even be more important than the military. WPB announced that the wonder drug penicillin, for three years practically a monopoly of the Army and Navy, was now being manufactured in such quantity that it can be issued to civilians." (Time, May 15, 1944, p. 61.)

Medical progress is still in the news and a chemotherapeutic agent even more wonderful than the sulfonamides has become available. People may look, but few see. No doubt many others before Alexander Fleming had looked at bacterial cultures accidentally contaminated with mold. But it remained for him to notice that the mold had cleared a wide, bacteria-free area between itself and the staphylococci on the plate. It was he who saw the potentialities of this observation. He soon found that a liquid in which this mold was grown, even when diluted 800 times, prevented the growth of staphylococci. Thus it was 2 or 3 times as strong in this respect as pure carbolic acid.

These events occurred in 1928. Eleven years passed before further progress took place. While penicillin was evidently a potent antibiotic, the problem of manufacturing it in adequate quantities seemed insuperable. Furthermore, the sulfonamides had been discovered in the meantime and seemed at first to make the need for the development of penicillin less important. At last, in 1938 Florey, Chain and their associates in England approached the problem again, seeking evidence of the value of penicillin in experimental

infections in mice and methods for its manufacture in quantity. They succeeded in making a highly concentrated preparation of penicillin which was effective experimentally and could be used in humans. But its production was difficult and cumbersome.

By this time, in order to coordinate scientific effort in the present war, there had been organized in this country under the Office of Scientific Research and Development (OSRD) and in collaboration with the National Research Council, means whereby the scientific facilities of the country and scientists in various fields, could be marshalled. Dr. Florey came to the United States and, with the aid of a special committee of the National Research Council, a major attack on the problem of penicillin production was made. In this work the United States Department of Agriculture as well as a number of the large pharmaceutical houses played an important role. Without doubt the needs of war and the scientific collaboration which the war has brought about, are responsible in large measure for the speed with which penicillin has been developed.

This new chemotherapeutic agent possesses many advantages as compared with the sulfonamides. These include its extraordinary speed of action, its effectiveness against organisms which the sulfonamides do not influence or which have become resistant to their action, and its lack of harmful effects. The speed with which penicillin acts, measured in hours rather than in days or weeks, is more dramatic in certain types of infection than even the most sanguine might have hoped for. A most unexpected finding is the value of penicillin in the treatment of early syphilis, a disease which is not influenced by the sulfonamides. These is good reason to hope that certain other infections, hitherto unaffected by any measures, may be cured by penicillin. The lack of toxicity of penicillin is all the more appreciated because we have learned that the sulfonamides sometimes produce harmful effects which may even prove fatal.

Medical Science and the War

During our own civil war four times as many men died from disease as from the wounds of battle. During World War I the mortality from battle casualties for the first time exceeded the deaths from communicable diseases. This was brought about by a combination of factors such as camp sanitation, prophylactic vaccination, personal hygiene, the isolation of disease carriers, contacts and suspects, and the practice of vigorous delousing. Modern warfare, thanks to the advances which have been described and to others which must still be mentioned, should have a much better record in spite of the fact that it is far more widespread than ever before and in spite of the new lethal agents that have been devised.

At Pearl Harbor not a single patient with a gunshot wound of the abdomen who reached the operating table alive and in whom the visceral wounds could be repaired, subsequently died. This can be attributed largely to the sulfonamide that was used. There never has been such a record in military surgery before. Penicillin, no doubt, will make the record even better.

The management of shock is just as important in the handling of the wounded as the control of infection. Shock is the state of general collapse that follows any severe injury or wound. It is often fatal and to avoid death immediate treatment is necessary. This war has brought the development of dried blood plasma, still the most valuable agent, other than whole blood, for the treatment of shock. Such plasma can be transported easily and after addition of water can be given the wounded even on the battlefield. This procedure, as well as the present highly developed system of field and hospital care and the use of transportation for the wounded, represent steps of enormous value.

The chief medical problem of the war probably is *malaria*. This is because our troops must operate in the regions where the bulk of the 3,500,000 deaths from malaria recorded annually occur. Never before have millions of men engaged in tropical warfare and thus this great disease predator has an unsurpassed opportunity to exert its influence. The capture of Java deprived us of the chief source of quinine but fortunately atabrine, a drug synthesized by the Germans following the first world war, is equally good if not better than quinine. Thousands of men have been given small doses of atabrine regularly for many months to hold in check malarial infection which could otherwise incapacitate them. Neither quinine nor atabrine, however, is an ideal antimalarial for neither will destroy certain stages of the parasite (sporozoites) or prevent mosquito-born infection. Neither drug completely cures tertian malaria although atabrine appears to be excellent in preventing the development of the most dreaded type of malaria, the so-called malignant tertian. A coordinated effort is being made to find better antimalarials than quinine or atabrine. For these experimental studies one per cent of the ducks in the United States are being used.

Control of malaria depends fundamentally on the prevention of bites by infected anophelene mosquitoes. Draining or filling mosquito breeding places, destroying the larvae there, screening buildings and spraying insecticides are measures employed at Army base installations. A "mosquite bomb" has been developed which employs pressure from the inert gas freon to discharge an insecticide far more effectively than can be done with a flit-gun. The most outstanding advance in insect control during this war has been the discovery of the remarkable insecticidal properties of DDT, which stands for dichloro-diphenyl-trichlorethane. Its use prevented a serious epidemic of typhus in Naples just as our troops arrived there and it is proving of great importance in the control of malaria.

The *war and modern transportation* have made acute the problem of transmission of disease by insects. Yellow fever, like malaria, is transmitted by mosquitos. Certain flies transport the trypanosome of African sleeping sickness. Bubonic plague is carried from rat to rat by the bites of fleas and from rats to man by the same insect. Lice transmit typhus and relapsing fever. These few examples indicate that insects carry viruses, bacteria, protozoa and spirochetes to man.

Thus, as Huff[5] has put it, "Long before man became air minded, some of the microbes were using insects for transportation." It is not difficult to imagine how, when this limited means of transportation is aided by mans' mechanical wings, the transmission of disease and the possible development in this country of what we once considered exotic diseases may become a very serious problem. "The flea which carries bubonic plague and normally hops a distance of 3 to 5 inches may possibly hop from one continent to another. Ticks, which are among man's worst enemies, have been restricted in their range by poor powers of locomotion. Will they discover our wings and 'hitch-hike' a million times as far?"[5]

In 1938 Whitfield investigated the insects found inside aircraft. He collected 277 species of insects and these included five species of mosquitos known to be capable of transmitting yellow fever and five species which can transmit malaria. There was also a specimen of tsetse fly which transmits African sleeping sickness, a bed bug, a flea, many horse flies, many species of house flies, cockroaches and black flies, and ten species known to be vectors of six different animal diseases. Rats have also been found in aircraft. It has been shown that mosquitos may survive journeys of over 9500 miles lasting for six and one-half days and that some of them though frozen on arrival have revived when they became warm again.

The danger lies not so much in infected insects biting several individuals and causing illness thereby, but in the possibility of their becoming established in the new region to which they have been transported. This occurred in Brazil and required much effort and expense to eradicate. The transportation of freight by aircraft will probably greatly facilitate the transfer of infected small animals, like rats.

Our own Public Health Service has been fully conscious of the possibilities of this mode of transmission of disease and measures had already been taken before the war to meet some of the problems which had been raised. Undoubtedly, however, with the rapid expansion of air transportation, vigilance will have to be keen if serious trouble is to be prevented.

Necessity has caused a new branch of medicine to develop to an unprecedented degree. The airplane of today functions better in the air than the man who flies it. The exploitation of all the possibilities of these extraordinary machines has been quite definitely hampered by the limitations of man's capacity for adjustment to unusual conditions. It has been the task of *aviation medicine* to find ways of adjustment to changes of barometric pressure, to reduction of air pressure, and to extraordinarily rapid changes in direction and acceleration. This has required an expansion of the study of physiology which will be valuable in many ways besides those related to flying.

It was learned in World War I that 90 per cent of the accidents in the air were due to errors of the pilot and that in some squadrons 50 per cent of the pilots were suffering from a neurosis which made them actually unfit for duty, though they continued to fly anyway. The problem has been enormously magnified in the present war.

Decreases in atmospheric pressure with increasing altitude are responsible for two of the major difficulties of the flier, namely the expansion of gases contained in the cavities, tissues and fluids of his body and the effects of lack of oxygen or anoxia. Although the body is capable of making some adjustments to the effects of changes in barometric pressure, these can not be made as quickly as our present machines are capable of rising.

One source of trouble is the expansion of intestinal gases. At 18,000 feet their volume is doubled as compared with that at sea level and at 33,700 feet it is quadrupled. With rapid rates of ascent these gases, instead of being eliminated, get caught in the intestinal loops and produce severe abdominal cramps. There is also the problem of the expansion of nitrogen, which constitutes 78 per cent of the air. This gas is dissolved in the body fluids in proportion to its partial pressure. When this pressure is reduced on ascending to a high altitude, if sufficient time is allowed the excess of dissolved nitrogen is brought by the blood to the lungs and is blown off. If ascent is very rapid, however, the gas is liberated before it reaches the lungs. Bubbles form in all the tissues with the result that the joints become stiff and sore, motion becomes impaired or is even totally inhibited (the "bends"), the skin itches and burns and giant hives may appear, and severe neuritic pain may develop owing to the large proportion of nitrogen which tends to accumulate in the fatty tissues of the nervous system. Bubbles forming in the brain may produce convulsions, paralysis and even death. One of the most distressing and dangerous complications is "the chokes," in which a burning sensation develops under the breast bone, followed by stabbing pain and progressive inability to breathe normally without coughing. Under combat conditions, as for example in interceptor planes which must take off at a moment's notice, there is often insufficient time for adequate desaturation.

The effects of lack of oxygen are insidious and not easily detected. Up to 10,000 feet the flier notices nothing except perhaps some increase in the rate and depth of respiration. A vague feeling of uneasiness may appear, the breathing becomes deeper and the pulse more rapid. Between 15,000 and 18,000 feet if he stays there for more than a couple of hours the flier is likely to experience severe headache, nausea and vomiting. Even with shorter exposures at this altitude, certain important mental changes occur. He may become rather depressed, sleepy and tired or elated, hilarious and aggressive even pugnacious. He may not remember what his course is supposed to be but he does not care. There is a marked resemblance to alcoholic intoxication. "Time sense is impaired and hours seem like minutes or vice versa. If he must perform any calculations, he finds that simple arithmetic is too much for him and his trembling pencil makes distorted figures on the paper. As he climbs above 20,000 feet his handwriting becomes a meaningless scrawl. His field of vision is constricted, the sky looks dark and the noise of the engine may be nearly inaudible. He is eventually unable to move a muscle and, at about 25,000 feet he passes into coma."[6] These ill effects can be met in large measure by the inhalation of oxygen. Regula

tions make its use compulsory above 10,000 feet. Unfortunately, however, some pilots in spite of rules see no reason for taking oxygen as long as they feel all right. Too many fail to realize that probably the most dangerous feature of oxygen want is the insidiousness of its approach.

The availability of oxygen through tanks is only one factor. At 40,000 feet, where planes are now flying, adequate oxygenation of the blood is maintained with difficulty owing to the lowered air pressure. Adequate pressure cabins or pressure tubes are required but these are not yet practical or available for routine use.

Everyone now is familiar with the need for equalization of atmospheric pressure on both sides of the ear drum. It is relatively easy to make this adjustment on rising to higher altitudes but the reverse is not accomplished as readily. The commercial airlines consequently do not permit descent at a rate faster than 300 feet per minute. The dive-bomber, however, may descend one hundred times as fast. The pilot of such a plane is hard pressed to ventilate his middle ear.

Speed of motion does not in itself demand physiologic adjustment but acceleration, that is, changes in rate or direction of motion, has profound effects upon the body. Imagine, for example, the effects of centrifugal forces on a pilot as he pulls up from a long straight dive. His "jaw sags open, there is a dragging sensation on his chest and abdomen as the internal organs are pulled downward, the limbs become so 'heavy' that it is impossible to move them; the legs feel tight and congested as indeed they are, and vision becomes blurred. If the stress is continued vision is lost completely ('black-out'), and later consciousness,"[6] is also lost. These effects are due in large part to the displacement of blood from the head to the abdomen and legs.

These are only some of the problems which confront the medical scientists who have been engaged in the study of aviation medicine. The selection of men most suitable for aviation, the development of maneuvers to meet the extraordinary acrobatics required in air warfare, the invention of equipment which is at the same time efficient and practical, are included in their tasks. Only when the war has been won and some of the details are no longer military secrets, will we know in full to what extent these problems have been met.

Approximately 30 per cent of the casualties in battle zones are psychiatric in nature. In the management of such casualties early and correct treatment is of the utmost importance if lasting neuroses are to be avoided. Rest, supported if necessary by sedatives, good food, quiet and reassurance before the casualty has been removed too far from the battle zone have served to make it possible for 70 to 80 per cent of the combatants to return to duty. Among the Australian forces at Tobruk there were 207 cases of neuroses. These comprised for the main part states of anxiety and fear. With early treatment 60 per cent of the men were restored fit for frontline service, whereas only 12 per cent had to be returned to Australia as permanently unfit.

In many other ways is medical science contributing to the war effort. Tank warfare, for example, has its own problems. Chemical warfare has others, both from the viewpoint of attack and that of protection. Malaria is only one of the plagues endangering our troops in the tropics. Limitations in the supply of blood plasma have led to a search for blood substitutes and this has already yielded many valuable results far outside the limits of the original problem. Food is one of the most important factors in war. This is not only a matter of vitamins but of energy supplying substances and minerals as well. Insufficiency leads to fatigue, lessened industrial efficiency, lowered morale and finally to unrest, riot and revolution. An ample reserve of fat and oil is important because these contain the largest amount of potential energy of any of the foods. We have none too ample a supply. Scurvy would have been a serious problem in the British Isles had it not been possible to furnish synthetic ascorbic acid in the place of the far bulkier citrus fruits for the shipment of which tonnage was lacking. We must meet food deficiencies in countries now being occupied and must stamp out the infectious diseases which always become rampant under such conditions and plague not only the immediate region but by their spread endanger the whole world.

When the full story of the role of science in the war effort is told, it will appear as an example of "team-work and cooperation in coordinating scientific research and in applying existing scientific knowledge to the solution of the technical problems paramount in war," of which we will all be proud. This coordination has been organized under the Office of Scientific Research and Development with the leadership of Dr. Vannevar Bush. The above quotation is taken from a letter addressed by President Franklin D. Roosevelt to Dr. Bush (Science, 100:542 (Dec. 15), 1944). The public is not aware of the ramifications of this work because for reasons of security much of it has necessarily had to be conducted in secrecy. "Its tangible results can be found in the communiques coming from the battle-fronts all over the world" (loc. cit.). Thousands o[f] scientists in universities and in private industry are engaged in thi[s] work. The development of penicillin and the attack on malaria ar[e] only two examples of the results of this coordinated effort in th[e] medical field. This work, valuable in war, will be just as importan[t] in peace for "the annual deaths in this country from one or tw[o] diseases alone are far in excess of the total number of lives lost b[y] us in battle during the war" (loc. cit.).

The Sum Total

One way of measuring the results of advancements in medic[al] science is the statistical. How long did the average newborn chil[d] live in former times, and what is its life expectancy today? Wh[at] is the life expectancy at other ages? How much has infant mortali[ty] been reduced?

During the industrial revolution in England when mothe[rs] began working in factories and were forced to leave their infan[ts]

with wet nurses or to be bottle fed with inadequate feeding formulas, the infant death rate was frightful. In Dublin, during the period 1775-1796, the mortality rate at the Foundling Hospital was 99.6 per cent.[4] At the beginning of the 19th century it was estimated that about one quarter of all children died before they reached two years of age. In London, during the period 1790 to 1805, 41.3 per cent of all children died before reaching the age of 5 years. The great historian Gibbon was the sole survivor of 7 children. Even as late as 1870, when proper mortality records first began to be kept in New York City, more than 38 per cent of infants born alive died before the age of 1 year. Infant mortality started to make a sharp decline about 1870. Today it is less than one tenth of the figure at that time.

A comparison has been made of life expectancy. Tables of life expectancy were made in Ancient Rome.[4] These showed that 2000 years ago the expectation of life at birth was about 22 years. In Massachusetts and New Hampshire in 1789 the expectation of life at birth was 28.2 years. In 1855 the figure had risen to 39.8. In 1901 it was 49 years. Today it is well over 60 years.

Such statistics indicate only deaths and fail to reveal the unhappiness and the economic loss produced by illness. These are difficult to record in numbers.

The expectancy of life in infants, children and young adults has increased greatly and even the middle aged person can expect today a longer life than could his ancestors of similar age. The data are favorable up to the age of 50 but after this age there is comparatively little difference between the Roman citizen's expectations and that of the man of 55, or more, today. This is a very significant fact because it points the way to the problems of the future. The leading listed causes of death in the United States in 1900 were influenza, pneumonia, bronchitis, tuberculosis, diarrhea, and heart disease, in the order named. These conditions accounted for almost 7 deaths per 1,000 population and of this number heart disease took about 1. In 1939, approximately the same number of deaths were caused by the following, in the order named: heart disease, cancer, brain hemorrhage, kidney disease, and lastly influenza, pneumonia, bronchitis and tuberculosis. Heart disease accounted for almost 3 of the 7 deaths, and cancer averaged more than 1 whereas in 1900 a number of other diseases took precedence over it.

The true significance of these facts can only be gathered by consideration of the average age of our population, because heart disease and cancer become much more frequent as age advances. The proportion of people over 65 years of age has almost doubled since 1900. This is due to the fact that the greatest advances in medical science have been made in the attack against the diseases of childhood and of young adults. These are the age periods in which the control of infection, the attack on contagious diseases, on tuberculosis and on typhoid fever, and the advances in nutrition have had their greatest effect. Advances in the treatment of pneumonia and diabetes will influence all ages. In comparison with the

advances in other fields, progress in the fields of cancer and heart disease including that produced by rheumatic fever, high blood pressure and hardening of the arteries has been insignificant. This is why these conditions seem to be more prevalent. Kidney disease, leukemia, various forms of rheumatism, many virus infections and many more diseases still stalk our path. We live, so to speak, to die of other things. We escape diphtheria in childhood but other unconquered enemies menace our later years.

The Medicine of Tomorrow

These then are some of the problems of medicine today. We have not touched upon the advances in the large and important field of industrial medicine nor on the problems there which remain to be answered. There has been no mention of endocrinology—the branch of science which deals with hormones. Remarkable discoveries have been made and much remains to be learned. We must bear in mind that the "wonder drugs" that have been discovered do not control all infections. There are many types of infection over which they have no influence; for example, most of the infections caused by viruses—infantile paralysis, rabies, sleeping sickness, influenza, parrot fever, yellow fever and the common cold.

Then again the problems of convalescence are rising in importance. When most of our efforts had to be directed towards the control of infection, we were in the main content to let convalescence take its own gradual course. Today, with the high premium on manpower that exists, and with the greatly improved methods for the management of infections, a legitimate impatience with the slowness of repair has arisen. This problem is pointed up by the needs of the Armed Forces, where a man is not regarded as well until he is ready to enter the firing line again. A reduction of even 33 per cent in the duration of convalescence would obviously be an important gain from a military standpoint, to say nothing of civilian life, where the industrial worker's time is likewise precious. Physical therapy, occupational therapy, re-education and rehabilitation take important places in the problems of convalescence. These problems are being attacked at present under the direction of the National Research Council. Our own laboratories, at their request, are at present engaged in the investigation of certain phases of this work.

Psychiatry has, relatively speaking, been a neglected field of medicine. Within the field of psychiatry must be included not only the late manifestations of mental disease which crowd our mental institutions and which, incidentally, represent an enormous and largely avoidable expense to the state, but also the much wider field of less obvious mental disorder which exists all about us and which profoundly influences not only the affected individual's well-being but that of his associates and of society in general.

We are only beginning to appreciate to what extent emotional and other psychological factors find expression in somatic complaints. Relatively few physicians have as yet been able to break the arbitrary barrier we have all been inclined to set up between mind and

body and too few are prepared to consider the patient as a single unit needing attention as such.

The medicine of tomorrow envisages the successful solution of these problems. With a wider appreciation of the value of research and increasing public support for such work, as well as with the lessons being learned under the pressure of war regarding the value of coordinated effort, there is every reason to believe that the hope for far greater success in the attack on disease than we have achieved so far, is not Utopian.

The advances in medical science which have been described, and many other important contributions to our knowledge which have not been mentioned because of lack of time, are of comparatively little value if the majority of the people do not profit by them. Medical knowledge has progressed rapidly but the application of these advances has lagged far behind. Witness the matter of tuberculosis. With a systematic, concerted effort, this disease could be stamped out. By means now available, x-ray films could be taken of our entire population at comparatively little expense. Hidden carriers of tuberculosis who are responsible for its continued spread could be detected and by simple measures these carriers could be rendered harmless. To bring this about, the public itself must be interested and must force upon its officials a demand for the adoption of the necessary steps. All too often pressure is brought on public officers only by those short-sighted individuals whose chief interest is in limiting public expenditures rather than by those who understand the value of efficient, far-sighted and advantageous use of public funds.

With proper measures, syphilis and gonorrhea can also be completely eradicated. The Scandinavian countries a number of years ago made these diseases medical curiosities instead of public menaces. Thanks to the leadership of the Public Health Service we are beginning to attack the problem of venereal diseases intelligently.

The importance of sanitation is common knowledge. But, strangely, we tolerate abuses all about us. Management of such matters is sometimes left in whole or in part to persons who may be indifferent or uninformed and who have no special training in the field of public health. Restaurants we frequent are allowed to be conducted in ways which offer opportunities for the spread of disease. Kitchen help in various institutions are employed without examination as to the likelihood of their transmitting disease, without instruction as to their public responsibilities or supervision as to their cleanliness. Unpasteurized milk is sold in certain communities which has been taken from cows inadequately inspected. This community is no exception to these criticisms. We wait for a serious epidemic to break out before giving thought to such matters. That is a very heavy price to pay.

In yet another important phase is the citizen failing to profit fully from the advances in medical science. Medicine has been so transformed in the past several decades that the examination of the individual is no longer a matter of the pulse, the temperature and

the appearance of the tongue. The more precise methods of the present day require x-ray equipment and laboratory facilities, some of which are complex and expensive. These in many instances are impossible to apply in the home or even in the average office. Thus we have seen the growth of clinics and specialists. The hospital has become the doctor's workshop; that is, the place where he has, or should have, at his disposal every new means for diagnosis and for treatment which science has devised.

These developments have led to a great increase in the cost of medical care. An adequate examination is more costly than the average person is prepared to pay if he makes no special provisions for such expenses. Health is still regarded as something which does not compare in the family budget with food, clothing and rent; yet every thinking person realizes that in the last analysis provision for health is good investment in ensuring the more obvious and seemingly more pressing matters of bread and butter. Means must be worked out whereby the whole community, the middle man as well as the rich and the poor, has access to the best in medical care. These means must not be stereotyped or routinized for good medicine cannot be practised in that way. The doctor-patient relationship and the right of the patient to the free choice of his physician must be preserved. That is a precious heritage without which it would be difficult to apply the advances of science to the full profit of the individual. We are confronted with a serious and complex economic problem which must be solved. Many students of the subject believe that the solution can be found by making improvements in the present methods of medical care rather than by extreme measures involving so-called "socialization" of medicine.

The well trained physician expects to practise his profession with the full utilization of modern knowledge and methods, even though these be costly. He has a right to expect this and a duty to inform his patient of the facilities which should be available to him. The patient, on his part should expect of his doctor an appreciation of the advances which are being made and an understanding of their application—or at least the physician must know, if the problem is somewhat complicated, how and where up-to-date methods and information can be obtained; for we have long passed the time when any single physician could apply and manage all the tools of medical science. It is not sufficient to have penicillin. Unless a diagnosis is made correctly and treatment initiated promptly, even this remarkable drug will fail.

The establishment of a four year medical school in your midst should aid in the attainment of many of these goals. A good medical school is much more than a trade school which offers to a certain number of young men and women the opportunity of learning "the what" and "the how" as they are known today. By providing facilities for and encouraging research it brings to your midst and fosters in your medical community a spirit of enquiry, a search for newer knowledge, an awareness of as well as the means for evaluating advances in medical science wherever they may have been discovered. Such a spirit of enquiry must be inculcated in th

medical student, for the best trained doctor and the most effective is the one who is able to think, to seek out, to evaluate and to apply.

A good medical school must also be the center for postgraduate medical education. The physician who does not remain a student all his life soon falls behind. His needs are not met by occasional attendance at meetings. It is only by weekly and even daily conferences and discussions with his fellows and with experts in various special fields, that he can keep up. These are things that your medical school should do for you and your physician.

* * *

Medicine has changed from an art based on a little knowledge, a greater or lesser amount of "common sense" and a certain degree of nonsense and even of charlatanism, to become more and more of an exact science. This progress has brought with it certain problems of practical application but it also offers opportunities for benefiting mankind which are truly great and must be exploited. The advances in medicine have opened up as many problems as they have answered. To fathom the goings-on in a mechanism so complex as the human body, to determine the chemical reactions which take place in the myriads of cells of microscopic size and of many different types which make up this organism, to learn the workings of the mind and its relation to the organism as a whole, to discover the reasons why these different structures sometimes fail to function normally and to find means whereby they can be restored to their normal activities, is a stupendous task the size of which only those who are familiar with the knowledge already gained can begin to appreciate. Yet the progress which has been achieved in this fascinating search makes one await with the keenest interest the discoveries of tomorrow.

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